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Case Report
TMJ Disorders

Treatment of traumatic dislocation of the mandibular condyle into the cranial fossa: development of a probable treatment algorithm

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Abstract. This study summarizes our experience of treating three rare cases of traumatic superior dislocation of the mandibular condyle into the cranial fossa and provides a potential treatment algorithm. Between the years 2002 and 2012, three patients with traumatic superior dislocation of the mandibular condyle into the cranial fossa were admitted to our department. After evaluating the interval from injury to treatment, the associated facial injuries including neurological complications, and the computed tomography imaging findings, an individualized treatment plan was developed for each patient. One patient underwent closed reduction under general anaesthesia. Two patients underwent open reduction with craniotomy and glenoid fossa reconstruction. All three patients were followed up for 1 year. Mouth opening and occlusal function recovered well, but all patients had mandibular deviation during mouth opening. Closed reduction under general anaesthesia, open surgical reduction with craniotomy, and mandibular condylotomy are the three main treatment methods for traumatic superior dislocation of the mandibular condyle into the cranial fossa. The treatment method should be selected on the basis of the interval from injury to treatment, associated facial injuries including neurological complications, and computed tomography imaging findings.

Key words: mandibular condyle; superior dislocation; middle cranial fossa.

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When the mandibular condyle collides with the top of the glenoid fossa of the temporomandibular joint (TMJ) under relatively strong external force, mandibular condylar neck fractures often occur due to the anatomical 'safety mechanism' for the skull base. For this reason, the incidence of mandibular condylar fracture is relatively high, representing 27–43% of mandibular fractures.[1–3] However, under certain anatomical or physiological conditions, the mandibular condyle may penetrate the mandibular fossa superiorly into the cranial fossa, and result in dislocation of the mandibular condyle into the cranial fossa (DMCCF). Such a situation is extremely rare. DMCCF was first reported in 1963, and up until 2012, only 45 cases had been reported sporadically in the English language literature.[4] The average age of these patients at the time of injury was 23.4 years and more than half were minors younger than 18 years of age. This injury is more common in female patients and the main cause is high-energy and high-speed traffic accidents.

Some special anatomical and physiological states may help explain the mechanism of this injury. Firstly, a small, round condyle may penetrate the glenoid fossa more easily than a normal, scroll-shaped condyle, which has been demonstrated experimentally by da Fonseca.[5] Yale et al.[6] reported that 2.8% of cadavers in their study had this kind of mandibular condyle. In addition, this morphology of the mandibular condyles is also found in 10-year-old children,[7] which may explain why this type of injury occurs most often in young people. Secondly, a high degree of pneumatization of the temporal bone weakens the top of the glenoid fossa and thereby reduces the resistance of the bone to impact.[8,9] Thirdly, the absence of posterior occlusion may lead to the consequence that any violent force is transferred directly to the TMJ along the ramus without being distributed to the maxilla via the teeth. Finally, if the patient opens the mouth at the time of impact to the chin, the violent force can be transferred directly to the condyle, which as mentioned above, lacks support from the teeth.

Mandibular asymmetry, limited mouth opening, and occlusal disorders are the main clinical features of DMCCF. These presentations are similar to the clinical manifestations of unilateral condylar fracture, which may lead to early-stage misdiagnosis and delayed treatment. Ohura et al.[9] and Spanio et al.[10] reported that misdiagnosis and delayed treatment occur in about half of these patients. Panoramic and plain radiographs cannot provide detailed information for diagnosis. Computed tomography (CT), especially coronal CT, is the main diagnostic imaging method. More than half of patients have no associated facial injuries, including neurological complications, but other injuries may include mandibular fracture, brain concussion, brain contusion, intracranial haemorrhage, epidural haematoma, cerebrospinal fluid leakage, hearing loss, ear canal injury, and facial nerve injury. Neurological complications and other associated facial injuries are important factors affecting the treatment strategy for DMCCF.

Three procedures have been reported for the treatment of DMCCF[4,8–23]: (1) closed reduction under general anaesthesia, (2) open surgical reduction with craniotomy, and (3) condylotomy. An individualized treatment based on the patient's status has been emphasized, and many scholars recommend similar treatment procedures.[4,9,21]

Between the years 2002 and 2012, three patients with DMCCF were admitted to our hospital. These three patients had injuries with different features and received individualized treatment. The treatment of these three patients is summarized below. We also reviewed the previous literature on this subject and concluded that the time interval between injury and treatment, the associated facial injuries including neurological complications, and CT imaging findings are the main factors affecting the treatment strategy.

Materials and methods

During the years 2002 to 2012, three patients with rare DMCCF were admitted to the department of oral and maxillofacial surgery of our institution. All patients or their legal guardians agreed to inclusion in this study and provided signed informed consent. All three patients were females, aged 13 years, 25 years, and 22 years. One patient was injured in a fall and two were injured in motor vehicle accidents (MVA). These three patients were admitted to our hospital 1 day, 2 weeks, and 5 months after they had sustained their injuries. The first two patients had no neurological complications. The third patient had a serious contusion of the brain at the time of the injury and presented to our hospital after recovering from the contusion; this patient had also suffered a delayed fracture of the mandibular body.

Spiral CT was carried out for all three patients on admission. After evaluating the time interval between injury and treatment, the associated facial injuries, and the CT imaging findings such as the depth of penetration of the condyle into the cranial fossa, we developed different treatment plans for the patients. One patient underwent closed reduction under general anaesthesia and the other two patients underwent open surgical reduction and glenoid reconstruction (Table 1).

Closed reduction

Case 1 was a 13-year-old female patient. The patient had accidentally fallen on her chin during exercise. After the injury she experienced limitations of mouth opening and malocclusion. The patient visited our hospital 6 h after the injury and no neurological complication was found. Physical examination showed deviation of the mandible towards the right side, 15 mm of mouth opening, an anterior open bite, and right-side premature contact of the posterior teeth. CT images showed a right-side glenoid fossa fracture and superior displacement of the right-side mandibular condyle into the skull (Fig. 1). The patient was undergoing orthodontic treatment.

Intermaxillary elastic traction was applied for 4 days, but failed. CT showed incomplete intracranial displacement of the mandibular condyle without incarceration. After an evaluation of the situation, a timely treatment plan of closed reduction under anaesthesia was made. Under general anaesthesia, the right mandibular body was held manually and pushed downward; force was applied mainly on the right lower molars. After several attempts, the mandible reduction was achieved. The occlusion was recovered and then intermaxillary fixation was performed. Postoperative intermaxillary traction was applied for 1 month, and then mouth opening exercises were started. The patient was followed up closely.

Table 1. Basic patient information.

Case	Gender	Age, years	Cause of injury	Interval between injury and treatment	Neurological complications	Treatment
1	Female	13	Fall	1 day	No	Closed reduction
2	Female	25	MVA	2 weeks	No	Open reduction with craniotomy
3	Female	22	MVA	5 months	Brain contusion	Open reduction with craniotomy

MVA, motor vehicle accident.

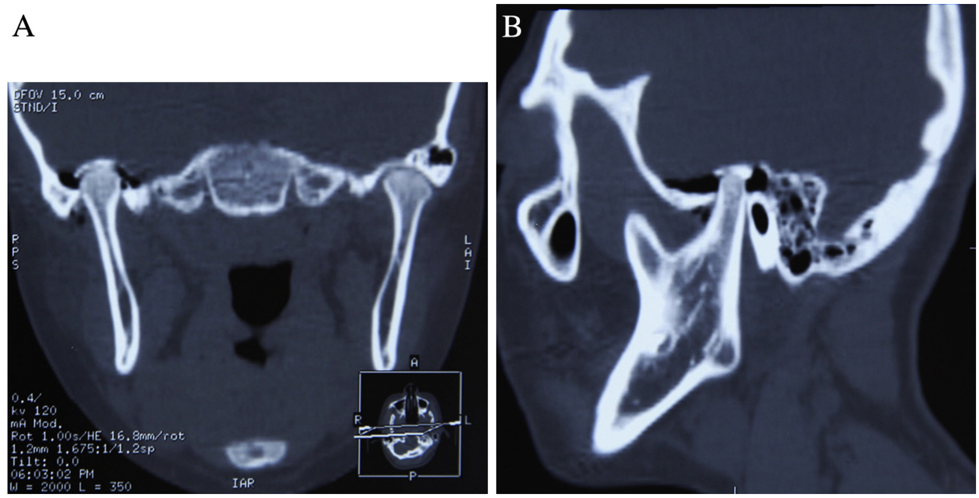

Fig. 1. Preoperative CT imaging findings of case 1. (A) Coronal CT scan: the right-side condyle displaced superiorly into the skull. (B) Sagittal CT scan: the pneumocephalus at the fracture site.

Open surgical reduction and glenoid reconstruction

Case 2 was a 25-year-old female patient. The patient had sustained a scalp contusion and maxillofacial injury during a MVA. The patient had no malignant vomiting or neurological complications after the injury. The patient was admitted to our hospital 2 weeks after injury due to a limitation in mouth opening and malocclusion. Physical examination showed a right-side deviation of the mandible, 1 cm of anterior open bite, and immobility of the mandible. CT examination showed a skull base fracture in the right glenoid fossa, displacement of the right mandibular condyle into the skull, and incarceration at the fracture site (Fig. 3). A treatment plan of open surgical reduction and simultaneous glenoid reconstruction was made.

A pre-auricular and coronal incision was made to expose the outer surface of the mandibular condyle, and a temporal bone window was made by a neurosurgeon at the site corresponding to where the condyle penetrated the cranial cavity (Fig. 4A). An epidural dissection was performed carefully to expose the condyle inside the skull (Fig. 4B). Bone fragments around the mandibular condyle were removed and an intermaxillary screw was drilled into the condyle for auxiliary traction. The condyle was pushed inferiorly using a periosteal elevator and pulled down with an extracranial wire on the screw to achieve reduction of the condyle. During surgery, a partial dural tear was observed; this was repaired using the temporal fascia tissue. Thereafter, the previously removed temporal bone was used to reconstruct the glenoid fossa and was fixed with a titanium miniplate. Titanium mesh was used to repair the defect in the temporal bone (Fig. 4C). The space between the glenoid fossa and the mandibular condyle was filled with the temporalis muscle and the wound was closed.

Postoperative examination showed that the occlusion was stable despite mandibular deviation still being present. The patient confirmed that the postoperative occlusion was consistent with the occlusion before injury, which suggested that the patient had mandibular deviation before the injury. Postoperative CT showed that the mandibular condyle was in the glenoid fossa and the joint position was good (Fig. 5). Intermaxillary traction was carried out for 1 month after surgery and the patient was followed up regularly.

Case 3 was a 22-year-old female who had suffered a serious brain injury and extensive skull base fracture during a MVA. The patient was in a coma for 2 months following the injury and visited our hospital 5 months after injury due to malocclusion. Preoperative CT showed a right-side mandibular body fracture, a comminuted right-side glenoid fracture, and DMCCF without bony adhesion between the condyle and the skull base (Fig. 6). The treatment plan comprised an open reduction with craniotomy and simultaneous glenoid reconstruction.

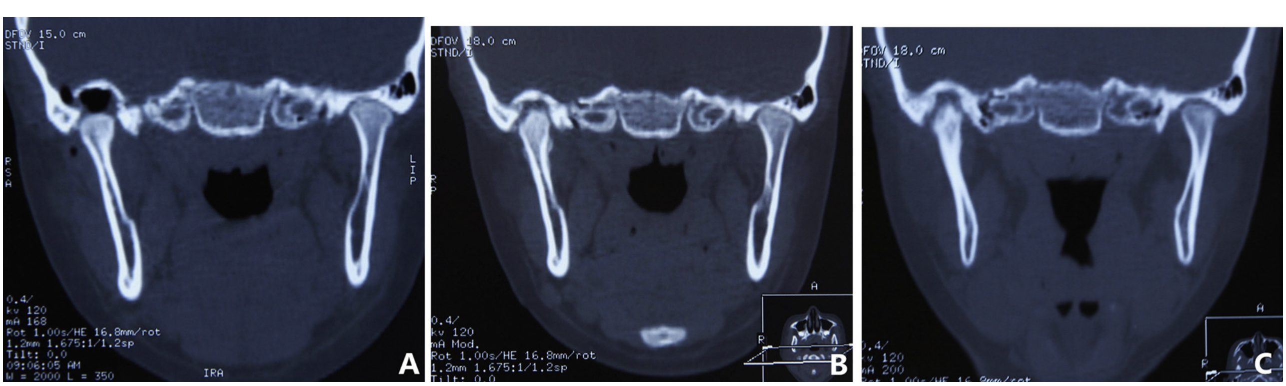

Fig. 2. Postoperative coronal CT scans of case 1. (A) Immediately postoperative: the condyle is repositioned and the pneumocephalus remains. (B) At 3 months postoperative: the pneumocephalus has disappeared. (C) At 1 year postoperative.

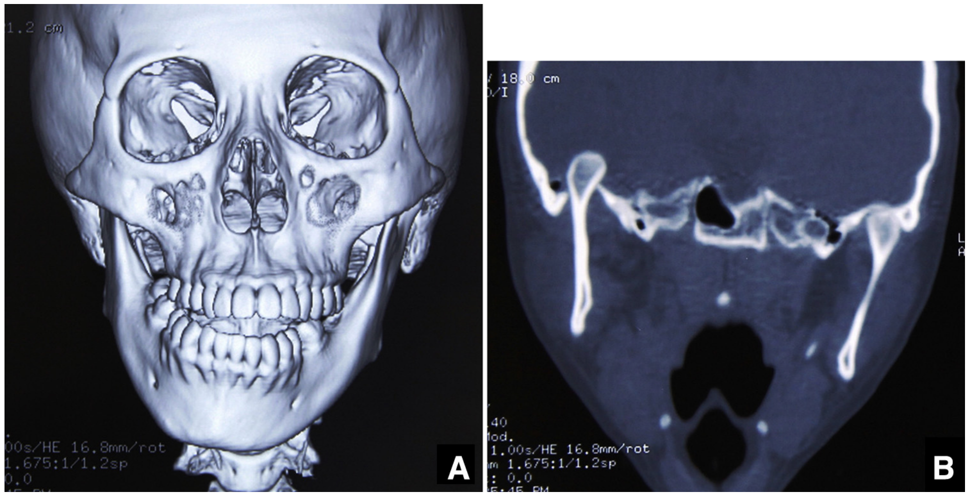

Fig. 3. Preoperative CT images of case 2. (A) Three-dimensional reconstruction CT scan. (B) Coronal CT scan: the condyle is displaced superiorly, deep into the skull.

A right-side pre-auricular and coronal incision was made and a neurosurgeon assisted in the surgery. Some parts of the temporal bone, zygomatic arch, and lateral bone plate of the glenoid fossa were removed. The dura was carefully dissected to expose the displaced mandibular condyle. The whole mandibular condyle was observed to have penetrated the middle cranial fossa and there was fibrous adhesion between it and the peripheral area of the glenoid fracture. After careful dissection, the mandibular condyle was found to be movable. The mandibular angle was clamped using a towel clamp and pulled inferiorly. At the same time, the intracranial mandibular condyle was pushed inferiorly into the glenoid fossa, and the reduction was achieved. The dura was then repaired using the temporalis muscle. Meanwhile, reduction and fixation of the ipsilateral mandibular body fracture was carried out. The temporal bone was trimmed, implanted into the defect of the glenoid fossa and fixed with a titanium plate. Wound closure was then accomplished.

Postoperative CT showed a satisfactory reduction of the mandibular condyle. Intermaxillary fixation was maintained for 1 month after surgery and the patient was followed up regularly.

Results

Intermaxillary traction was performed for all three patients for 1 month and the patients were followed up for 1 year. Postoperative occlusion was good for all three patients, and the mouth opening ranged from 35 to 38 mm. However, all three patients had some degree of mandibular deviation while opening the mouth.

For the first case, CT scans taken immediately after surgery showed that the right mandibular condyle had been placed back into the glenoid fossa. No secondary intracranial haemorrhage was observed, although pneumocephalus remained (Fig. 2A). CT scans done at 3 months after

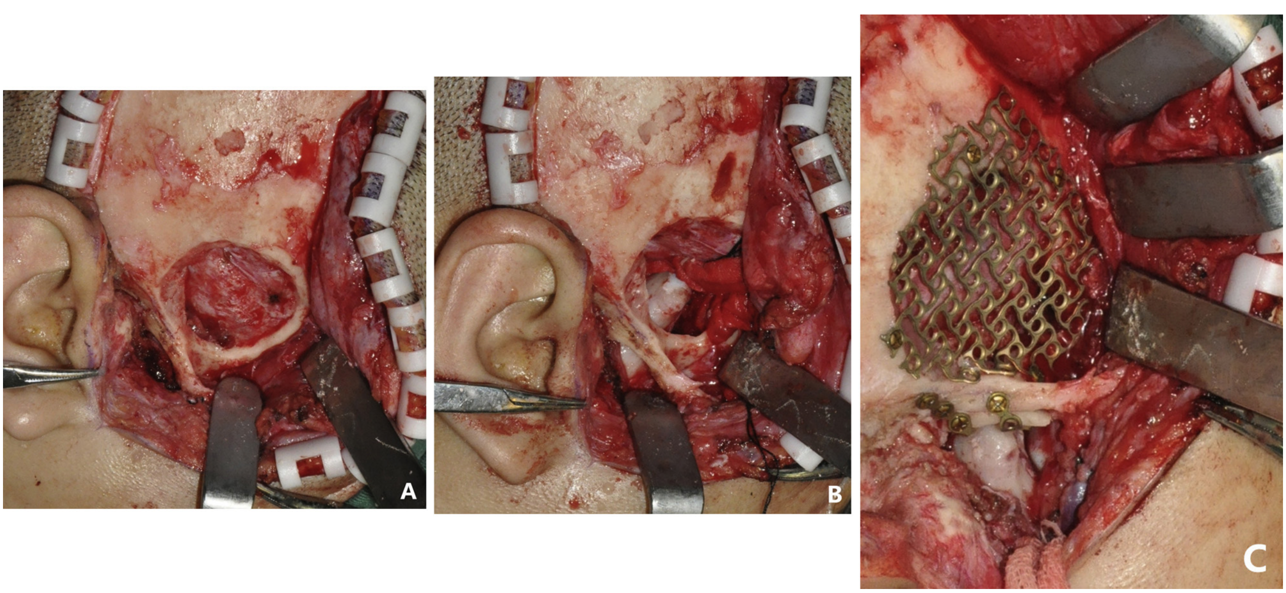

Fig. 4. Photographs of the open reduction surgery in case 2. (A) Temporal craniotomy. (B) Exposure of the mandibular condyle dislocated into the skull. (C) Condyle reduction, glenoid reconstruction using the temporal bone, and repair of the temporal defect using titanium mesh.

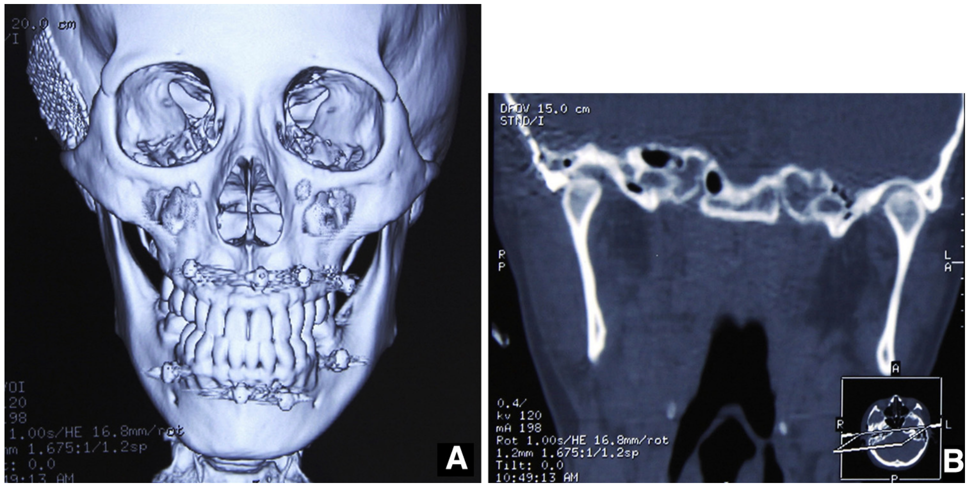

Fig. 5. Postoperative CT scans of case 2 at 1 year. (A) Three-dimensional reconstruction CT scan. (B) Coronal CT scan: the condyle is repositioned into the glenoid fossa.

surgery showed that the pneumocephalus had disappeared, the fracture at the top of the glenoid fossa had healed, and a new morphology of the glenoid fossa had formed (Fig. 2B). One year after surgery, the orthodontic treatment was completed and the occlusion was normal. The range of mouth opening was 38 mm with a right-side mandibular deviation on mouth opening. CT images showed that the joint position was stable (Fig. 2C).

At the 1-year follow-up of the second case, the appearance and occlusion were the same as they had been before the injury; the range of mouth opening was 36 mm with a right-side mandibular deviation.

For the third case, the range of mouth opening at 1 year after surgery was 35 mm and the occlusion was restored, however there was right-side mandibular deviation on mouth opening.

Fig. 6. Preoperative CT image of case 3. The condyle has penetrated the skull, and there is no bony adhesion between it and the peripheral skull base.

Discussion

A review of the literature revealed three methods used for the treatment of DMCCF: closed reduction under general anaesthesia, open reduction with craniotomy (with or without glenoid reconstruction), and condylotomy.[4,9,21] All three methods have their own advantages and disadvantages. Closed reduction under general anaesthesia does not involve open surgery, so it is minimally invasive and suitable for the early treatment of patients who have no incarceration of the mandibular condyle. However, there is the possibility of secondary intracranial haematoma after treatment. Such cases should be observed closely for neurological complications after closed reduction. Without reconstructing the glenoid fossa, relatively long-term intermaxillary traction is required after surgery.

Open reduction can achieve definite restoration of the joint position and can be performed simultaneously with glenoid reconstruction. The recovery of joint function is good. However, this method is relatively more invasive and requires the cooperation of maxillofacial surgeons and neurosurgeons. In addition, it may result in secondary brain injury, intracranial infection, and cerebrospinal fluid leakage. This method is suitable for cases in which closed reduction during early treatment has failed and where there is deep protrusion of the mandibular condyle into the cranial fossa. For cases in which treatment has been delayed for more than 4 weeks, this method can be used if there is no bony adhesion between the condyle and the peripheral bone. Cases with neurological complications will require consultation with neurosurgeons. Open reduction can be achieved when managing neurological complications including intracranial haematoma with open surgery.

The principle of condylotomy is similar to that of surgical treatment of TMJ ankylosis. This method can avoid neurological complications including brain injury, but it may seriously affect joint function. This method is suitable for cases with delayed treatment, where there is extensive adhesion between the mandibular condyle and the skull base.

Adopting an appropriate method is important in the treatment of DMCCF. In a review of the literature, Koretsch et al.[21] recommended that a definite diagnosis should be carried out based on CT scans. For patients with no associated fractures, who do not require a neurosurgical intervention, and for whom an early diagnosis has been made, closed reduction under general anaesthesia should be attempted after fibre optic nasal intubation. CT scans should be carried out immediately after treatment to exclude secondary brain injuries. For cases with associated facial fractures or neurological complications, delays in treatment, or a failed closed reduction, more aggressive surgical treatments such as condylotomy and open reduction should be considered. Ohura et al.[9] suggested performing closed reduction in young patients treated within 4 weeks of injury, and that open reduction should only be considered after closed reduction has failed or for patients who are receiving treatment more than 4 weeks after injury.

The review of the literature and our treatment experience with the three cases presented herein indicate that three factors affect the choice of treatment plan: (1) the time interval between injury and treatment, (2) the presence of neurological complications and associated facial injuries, and (3) CT imaging findings.

For patients treated early, closed reduction should be applied if there is no obvious incarceration of the condyle. Any treatment delay can add to the difficulty of this procedure. This view is consistent with that of other scholars. However, the time frame distinguishing early and delayed treatment is not fixed, although most scholars use 4 weeks as a reference limit.

The treatment plans for DMCCF patients need to be established with close cooperation between oral–maxillofacial surgeons and neurosurgeons. Neurological complications and associated facial injuries are the main factors affecting decisions. In the review of Ohura et al.,[9] they reported that more than half of 45 patients had no neurological complication or other associated injuries, but that the remaining patients had associated injuries including brain concussion, cerebral contusion, intracranial haemorrhage, epidural haematoma, cerebrospinal fluid leakage, hearing loss, ear canal injury, and facial nerve injury, and that 15 cases had mandibular fractures at 19 sites. When open surgery is required to treat a neurosurgical emergency such as a subdural haematoma, the DMCCF should be treated simultaneously. Struewer et al.[4] reported a DMCCF case in which open surgery was required for an associated epidural haematoma; simultaneous reduction of the mandibular condyle was carried out at the time of haematoma removal and performing haemostasis. If no emergency surgery is needed to address neurological complications, whether other maxillofacial injuries require surgical treatment should be taken into account. If open surgery is needed, a simultaneous open reduction of the displaced mandibular condyle should be considered.[21]

CT, especially coronal CT, is the first choice of examination to diagnose DMCCF and to devise the treatment plan. CT images should be examined to determine the depth of condyle protrusion into the cranial fossa and to identify the presence of incarceration at the site of the glenoid fracture. For patients who are undergoing early treatment, open reduction with a craniotomy may be safer and more effective than closed reduction if there is significant incarceration of the condyle at the site of the glenoid fracture.

No comprehensive CT data were provided in case reports before the 1990s. Three reports in which closed reduction under general anaesthesia was performed successfully have been published since 1995, by Barron et al.,[19] Koretsch et al.,[21] and Harstall et al.[17] In the first two reports, CT images showed that the widest parts of the condyles had not entered the skull. In the last report by Harstall et al.,[17] the location of the condyle was not displayed clearly in the CT images because the window width was chosen for soft tissues. However, no incarceration at the basilar skull fracture site was apparent. Nine reports have described performing open reduction or a mandibular condyle osteotomy for cases treated within 4 weeks of injury.[9–14,16,18,22] In these cases, CT images showed that the mandibular condyles protruded deep into the skull, the widest part of the condyle had entered the skull, and closed reductions failed.

For patients undergoing delayed treatment, the degree of adhesion between the mandibular condyle and the associated peripheral bone should be observed. Surgeons should identify whether adhesiolysis and reduction of the mandibular condyle can be achieved by surgery, rather than simply performing a mandibular condyle osteotomy. In the third case presented herein, although the patient received treatment 5 months after injury, no obvious adhesion was shown on CT, and an open reduction was performed successfully.

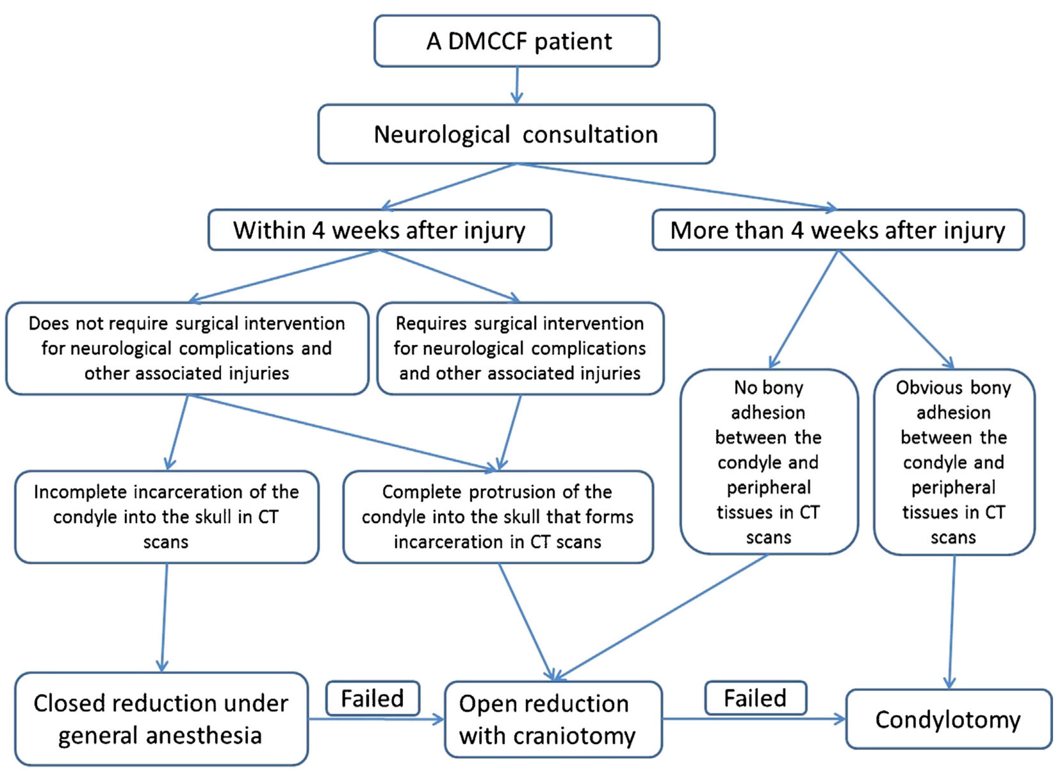

Fig. 7. The treatment algorithm for patients with dislocation of the mandibular condyle into the cranial fossa.

In conclusion, we introduce a treatment algorithm for DMCCF (Fig. 7) based on the three reference factors: (1) interval between injury and treatment, (2) neurological complications and associated facial injuries, and (3) CT imaging findings. The first two factors are consistent with those reported by other scholars. We consider that CT imaging findings also constitute an important factor.

A pneumocephalus at the fracture site was shown in the CT scans of the first case. It was speculated that this was derived from air cells in the temporal bone. After closed reduction, the pneumocephalus remained. In the CT scans obtained at 3 months after treatment, the pneumocephalus had disappeared. After treatment, all three patients recovered with normal mouth opening and occlusion. However, all had deviation of the mandible during mouth opening. This result has also been reported by others,[16] and it may be related to injuries to the lateral pterygoid muscles attached to the medial side of the condyle.

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Competing interests

None.

Ethical approval

This study was approved by the ethics committee of Peking University School and Hospital of Stomatology (No. PKUSSIRB-2012071).

Patient consent

All patients or their legal guardians provided signed informed consent for publication of the images.

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